

We claim:

1. A electrode/electrolyte structure for a fuel cell comprising an inorganic electrolyte sheet incorporating a plurality of positive air and negative fuel electrodes bonded to opposing sides of the electrolyte sheet, the electrodes being electrically connected in series, parallel, or a combination thereof by means of vias through the electrolyte sheet filled with electronically conducting material.
2. A structure in accordance with claim 1 wherein the inorganic electrolyte sheet is a solid oxide electrolyte sheet.
3. A structure in accordance with claim 1 wherein the vias are filled with metallic conducting material.
4. A structure in accordance with claim 1 wherein the vias are filled with a metallic conducting material selected from the group of semi-precious and precious metals and metal alloys.
5. A structure in accordance with claim 1 wherein the vias are filled with a cermet composed of a metallic conducting material and a ceramic material, the ceramic material being selected from the group consisting of alumina, yttria-doped zirconia, and doped lanthanum chromite wherein the dopant is Mg, Ca, or Sr.
- 6.. A structure in accordance with claim 1 wherein the electrodes comprise a conductive metal phase and a ceramic phase
7. A structure in accordance with claim 6 wherein the conductive metal phase is silver or silver alloy.
8. A structure in accordance with claim 6 wherein the ceramic phase is a polycrystalline ceramic selected from the group consisting of stabilized zirconia, partially stabilized zirconia, stabilized hafnia, partially stabilized hafnia, mixtures of

zirconia and hafnia, ceria with zirconia, bismuth with zirconia, gadolinium, germanium, and mixtures thereof.

5 9. A structure in accordance with claim 6 wherein the ceramic phase is selected from the group consisting of partially stabilized zirconias or stabilized zirconias that are doped with a stabilizing additive selected from the group consisting of the oxides of Y, Ce, Ca, Mg, Sc, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, In, Ti, Sn, Nb, Ta, Mo, and W and mixtures thereof.

10 10. A structure in accordance with claim 1 wherein the electrolyte sheet has a composition comprising 3-10 mole % yttria and 90-97 mole % zirconia.

15 11. A fuel cell apparatus containing at least one electrode/electrolyte structure formed of an array of positive air electrodes and negative fuel electrodes disposed on opposing sides of a solid oxide electrolyte sheet, the positive and negative electrodes being electrically connected by electrical conductors traversing vias in the electrolyte sheet.

20 12. Apparatus in accordance with claim 11 wherein the vias are filled with an electrical conductor selected from the group consisting of semi-precious and precious metals and metal alloys.

13. Apparatus in accordance with claim 11 operating at a temperature of less than 850° C.

25 14. Apparatus in accordance with claim 11 wherein the positive and negative electrodes comprise a conductive metal phase and a ceramic phase and are electrically connected by conductors traversing vias in the electrolyte sheet.

30 15. Apparatus in accordance with claim 11 having a total single-cell internal resistance below 1 ohm-cm<sup>2</sup>.

16. Apparatus in accordance with claim 11 wherein the electrolyte sheet is composed of a polycrystalline ceramic having a composition selected from the group consisting of partially stabilized zirconias or stabilized zirconias that are doped with a stabilizing additive selected from the group consisting of the oxides of Y, Ce, Ca, Mg, Sc, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, In, Ti, Sn, Nb, Ta, Mo, and W and mixtures thereof.

17. Apparatus accordance with claim 11 wherein the negative fuel electrode contains nickel.

18. Apparatus accordance with claim 11 wherein at least one of the positive air electrode and the negative fuel electrode further comprise an oxide overlayer.

19. Apparatus accordance with claim 18 wherein the oxide overlayer is composed of lanthanum strontium cobaltate.

20. Apparatus in accordance with claim 11 wherein the fuel cell has a geometry that varies in shape or area.

21. Apparatus in accordance with claim 11 wherein the fuel cell has a geometry wherein at least one electrode/electrolyte structure varies in shape or area.

22. A solid oxide fuel cell comprising:

a plurality of positive air electrodes and negative fuel electrodes, both the positive and negative electrodes having a composition comprising a conductive metal phase and a ceramic phase;

a electrolyte sheet interposed between the positive air electrodes and negative fuel electrodes, the positive air electrodes being bonded to a first side of the electrolyte sheet and the negative fuel electrodes being bonded to a second side of the electrolyte sheet; the positive and negative electrodes being in opposing positions across the electrolyte sheet to form a plurality of electrochemical cells on the sheet; and

the plurality of cells being connected in electrical series, parallel, or a combination of series and parallel by means of cell interconnects contacting the electrodes and traversing a plurality of vias formed in the electrolyte sheet.

5 23. A method of making an electrode/electrolyte structure for a solid oxide fuel cell comprising the steps of:

providing a ceramic electrolyte sheet comprising a plurality of vias therethrough;

10 forming a plurality of cathode segments on a first side of the electrolyte sheet and a plurality of anode segments in opposition to the cathode segments on a second side of the electrolyte sheet; and

forming electrically conducting interconnects traversing the vias from the first side to the second side, each interconnect being in contact with at least one cathode segment on the first side and at least one anode on the second side of the sheet.

15 24. The method of claim 23 wherein the electrolyte sheet is a sintered ceramic electrolyte sheet, wherein the electrically conducting interconnects comprise a conductive sintered via fill material, and wherein the via fill material is co-sintered with one or more of the electrodes or other fuel cell components.

20 25. A method of making an interconnect structure comprising the steps of:

providing a sintered ceramic electrolyte sheet comprising a plurality of vias therethrough; and

25 forming electrically conducting interconnects traversing the vias from a first side to a second side of the sheet.

30 26. A method in accordance with claim 25 wherein the sintered ceramic electrolyte sheet is a sheet wherein the plurality of vias have been formed by mechanical punching or laser machining of the sheet prior to sheet sintering.